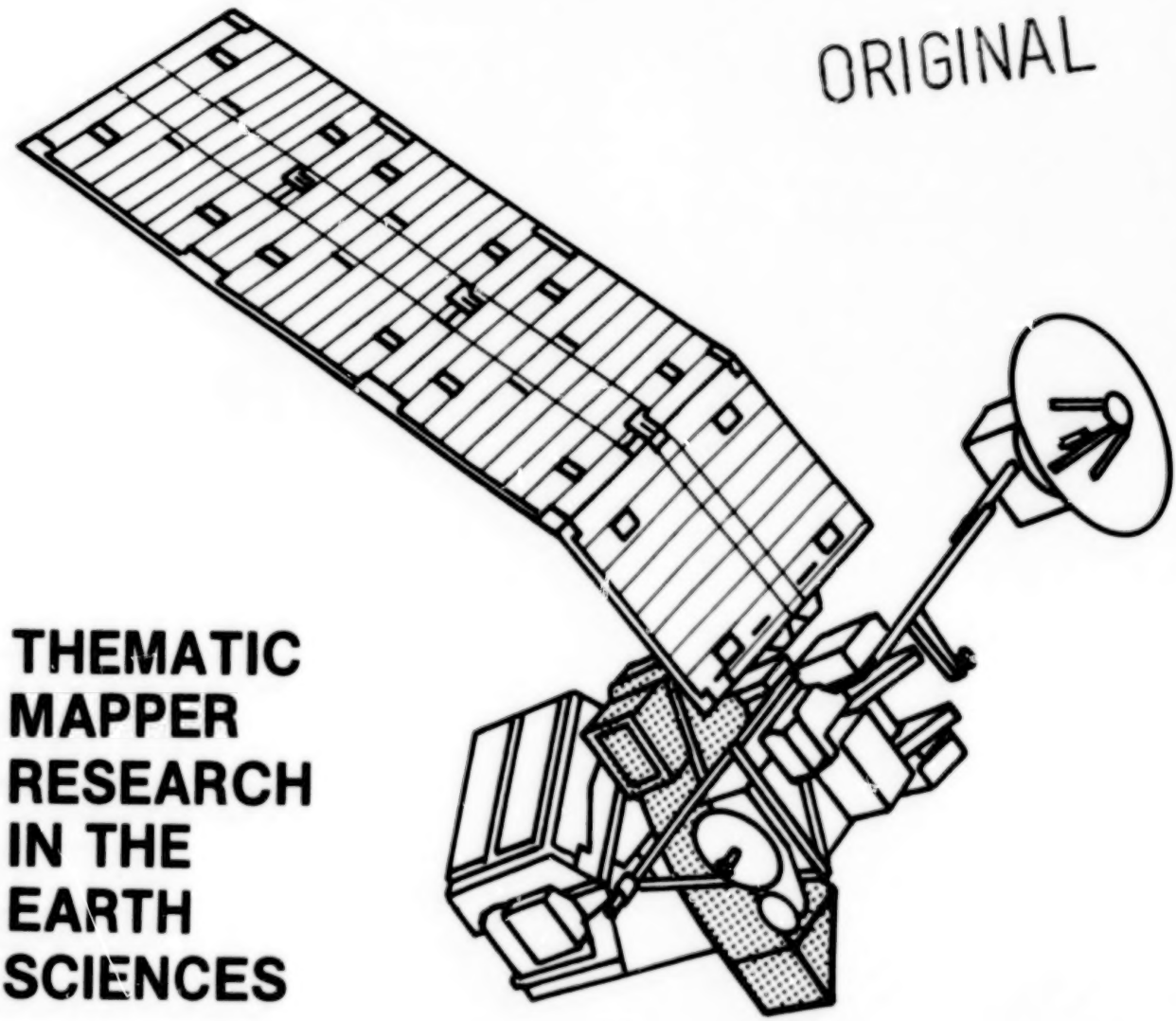
NASA
National Aeronautics and Space Administration

Announcement of Opportunity



THEMATIC MAPPER RESEARCH IN THE EARTH SCIENCES

A.O. NO. OSSA-3-84
July 27, 1984

ANNOUNCEMENT OF OPPORTUNITY

THEMATIC MAPPER RESEARCH IN THE EARTH SCIENCES

I. DESCRIPTION OF THE OPPORTUNITY

The National Aeronautics and Space Administration (NASA) announces the opportunity to conduct basic scientific studies of the Earth employing the unique observational capabilities of the Landsat Thematic Mapper (TM). The TM is an advanced remote sensing system designed to measure the intensity of Earth radiation within selected portions of the electromagnetic spectrum. The TM is able to conduct multispectral surveys of Earth radiation at a level of resolution and sensitivity that surpasses all previous sensor systems placed in Earth orbit. Section IV of this document provides a more detailed description of the TM and the procedures involved in the acquisition and reduction of TM data.

The scientific investigations sought by this Announcement of Opportunity differ fundamentally from many of the Landsat research activities sponsored by NASA in the past. The use of orbital multispectral imagery for studies of the Earth's surface began in earnest in the mid-1970's following the launch of Landsats 1 and 2. Landsat investigations sponsored by NASA during the mid-1970's were primarily designed to evaluate the various types of information that could be inferred from Multispectral Scanner (MSS) imagery. These early research efforts attempted to relate observed variations in the spectral characteristics of the Earth's surface to the physical and chemical properties of surficial materials. The success of these investigations provided a basis for deriving information about the nature and condition of surface materials from multispectral Earth imagery acquired at a synoptic scale. Landsat investigations sponsored by NASA during the late 1970's were primarily designed to explore practical applications of orbital multispectral surveys. During this period, NASA conducted a variety of projects in collaboration with other government agencies and private industry to evaluate the practical utility of Landsat MSS data for crop forecasting, mineral exploration, water resource management, etc.

Research to be initiated under the auspices of this Announcement is expected to build upon the results of these earlier investigations but to differ substantially in intent and scope. The purpose of this research program is to develop improved understanding of surface conditions and processes on the Earth through the analysis and interpretation of TM data. It is anticipated that proposals submitted in response to this Announcement will identify topical problems in various aspects of the Earth sciences that can be addressed in new and innovative ways through the analysis of orbital TM imagery. Proposals are specifically sought for investigations in the fields of botany, ecology, geology, hydrology, and related Earth science disciplines.

Earlier Landsat research programs have provided considerable insight into the general types of Earth science studies that can potentially be conducted with multispectral Earth imagery collected at synoptic scales on a repetitive, global basis. In addition, a variety of experiments have been conducted during the past eight years employing multispectral imagery acquired by airborne sensors that simulate the general measurement capabilities of the TM. These airborne TM simulator experiments have provided considerable insight into the various types of Earth information that can potentially be inferred from orbital TM imagery. The results of earlier MSS data analysis projects and TM simulator studies are available in the open scientific and technical literature. (A bibliography of key references to relevant publications is provided in Appendix C for prospective proposers.) The collective results of these earlier investigations provide a framework for defining specific scientific hypotheses concerning terrestrial conditions and processes that can be addressed in an innovative fashion with the TM.

The research program described in this Announcement will be initiated in 1985 and continued through 1987. Proposals may be submitted for investigations ranging from one to three years in duration. Two types of proposals will be considered: (1) those requesting NASA funds to support the analysis and interpretation of TM data and (2) those that require TM data but do not require financial support by NASA. The latter type of proposal may be submitted by foreign (non-U.S.) research institutions or by private organizations which could potentially benefit from participating in this type of data analysis activity.

A total of approximately five million dollars is available to conduct this research program. However, this Announcement does not constitute an obligation on the part of the U.S. Government to provide such funds for this purpose. It is anticipated that a total of 20-30 proposals will be approved, depending on the scope and complexity of individual investigations. The results of these investigations will subsequently be published in the open scientific literature.

Each proposal should identify a single individual who will serve as the Principal Investigator for the proposed study. The Principal Investigators of those proposals selected by NASA will be appointed to a Thematic Mapper Science Working Group (TMSWG). The TMSWG will meet periodically in whole or in part to review the results of ongoing research activities. The TMSWG will receive routine briefings on TM sensor performance, TM image quality, and the status of the TM data collection. In addition, the TMSWG will provide a forum for the discussion of data analysis techniques and approaches among investigators with diverse disciplinary backgrounds. This working group will be headed by the Landsat Project Scientist. Dr. Vincent Salomonson of NASA's Goddard Space Flight Center currently serves as the Landsat Project Scientist.

The first TM sensor placed in Earth orbit was carried into space on July 16, 1982, on the Landsat 4 spacecraft. Landsat 4 developed a series of technical problems during the first quarter of 1983 that severely curtailed the subsequent collection of TM data. A second TM sensor was successfully placed in Earth orbit on March 1, 1984, on the Landsat 5 spacecraft. The Landsat 5 TM and the Landsat 5 spacecraft are operating nominally at the present time.

It is currently anticipated that Landsat 5 will serve as the principal source of TM data for the scientific investigations conducted under the auspices of this Announcement of Opportunity. However, prospective investigators may include requests for previously acquired Landsat 4 TM data in their proposals. Landsat 4 TM imagery was primarily acquired over North America between September 1982 and February 1983. The utility of this image collection for studies of terrestrial surface conditions is restricted by the extensive cloud and snow cover that is prevalent during the fall and winter seasons in the Northern Hemisphere. In addition, the low solar elevation angles that occur throughout the fall and winter produce extensive shadowing in Landsat 4 TM imagery of high relief areas. A complete listing of the Landsat 4 TM scenes that have been fully reduced to image format can be obtained upon request from the EROS Data Center, Sioux Falls, South Dakota 57198.

The National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce will assume responsibility for TM operations and data processing in January 1985. However, the investigators selected to participate in this research program will submit their requests for TM data acquisition and processing to NASA. These requests will be compiled and centrally coordinated by the Landsat Project Scientist at NASA's Goddard Space Flight Center. NASA will assume all responsibility for providing TM data to the domestic and foreign scientists selected to participate in this research program (see Section VI).

Readers of this Announcement should realize that they do not need to submit a proposal to NASA to gain access to the TM data that will be collected under the auspices of this research program. All TM data collected for approved program investigators will be made available to the general public through the EROS Data Center (EDC). (Landsat data distribution services at EDC are currently being operated by the U.S. Geological Survey for NOAA.) TM data will be made available to the general public at the same time that it is released to an approved program investigator from the NOAA archive at EDC.

II. ANNOUNCEMENT OBJECTIVES

To be selected, proposals submitted in response to this Announcement must identify a topical problem in one or more Earth science disciplines that can be addressed in an innovative fashion employing the Landsat TM. The overall objective of this Announcement is to develop improved understanding of surface conditions and processes on the Earth through the analysis and interpretation of space acquired TM data. It is anticipated that successful proposals will address scientific objectives of the following nature:

- to develop an improved understanding of the factors influencing the growth, health, condition, and distribution of vegetation on the Earth
- to develop an improved understanding of the processes controlling the structural and chemical evolution of the Earth's crust, and the geological history of specific crustal provinces
- to develop an improved understanding of the Earth's water budget and hydrologic processes that operate at local, regional, and global scales
- to develop an improved understanding of the physical and chemical interaction between different types of surficial materials such as rocks, soils, vegetation, and water
- to develop an improved understanding of the interaction between the Earth's surface and its atmosphere over a variety of temporal and spatial scales

These objectives are presented here in a very generalized fashion. It is expected that individual proposals will identify specific topical problems that can be addressed in a meaningful fashion during a one-to three-year period of investigation.

III. BACKGROUND

The collection of scientific investigations sought by this Announcement of Opportunity represents one part of a much broader program being conducted by NASA to evaluate the Earth observation capabilities of the TM. Related TM research activities currently in progress are designed to: (1) assess the quality of TM imagery with respect to specifications that were established prior to the launch of Landsats 4 and 5, (2) validate the results of airborne TM simulator experiments conducted in the past, and (3) evaluate the relative utility of orbital MSS and TM imagery for various types of Earth observations. The nature and scope of these related research efforts are briefly described in this section. The results of these related R&D activities are reported in various technical publications referenced in Appendix C of this Announcement.

In October 1981, NASA released an Applications Notice for Landsat Image Data Quality Analysis (LIDQA). The purpose of the LIDQA program is to evaluate the orbital performance of the Landsat sensor payload and the ground-based performance of the computer system which is used to produce Landsat imagery. Thirty-two investigators were selected to participate in this research program. These investigators are studying the radiometric and geometric characteristics of orbital TM data in both raw and processed forms. They are currently comparing the observed characteristics of TM data products with data quality specifications that were established prior to the launch of Landsats 4 and 5. The results of these investigations have provided important insight into the orbital behavior of the TM and the accuracy of various computer algorithms that have been developed to calibrate and rectify multispectral TM imagery. The results of the LIDQA program have been used to modify and improve the various correction procedures that are routinely employed in the reduction of raw TM data.

Prior to the launch of Landsat 4, NASA developed and operated a series of airborne multispectral scanners that simulated the general measurement capabilities of the TM. Analysis of the data acquired by these instruments enabled researchers to develop considerable intuition regarding the physical attributes of the Earth's surface that could potentially be inferred from TM imagery. A variety of studies are currently underway to determine if similar types of surficial information can be inferred from orbital TM surveys which are conducted from above the Earth's atmosphere over a much broader spatial scale.

A considerable body of knowledge has been developed during the past twelve years concerning the various types of surficial information that can be inferred from Landsat MSS imagery. A wide variety of investigations is currently underway both inside and outside of NASA to evaluate the relative utility of TM and MSS data for specific types of Earth observations. Many of these investigations are being conducted by other government agencies and private sector companies without direct NASA sponsorship. However, NASA is interested in comparing the various types of information that can be derived from TM and MSS imagery and relating improvements in the observational capabilities of the TM to specific improvements in the technical measurement capabilities of the TM sensor (i.e., its instantaneous field-of-view, spectral resolution, radiometric sensitivity, etc.). Studies of this nature produce results that have a direct bearing upon advanced technology development programs currently underway at NASA.

The Earth science investigations sought by this Announcement of Opportunity differ significantly from the TM investigations described above. The purpose of this Announcement is to identify a series of scientific questions in various terrestrial disciplines that can be addressed in fundamentally new and innovative ways employing the unique observational capabilities of the TM. It is anticipated that these investigations will provide greater insight into the quality and practical utility of TM imagery. However, results of this nature are not considered to be the principal objectives of this program. The desired outcome of the Earth science TM investigations sought by this Announcement is improved understanding of global conditions and surface processes on our planet. Proposals that are not responsive to the specific opportunity described in this Announcement will be returned to their authors.

IV. CAPABILITIES AND PERFORMANCE OF THE TM SYSTEM

An understanding of the system that is used to acquire and reduce Landsat TM data is essential to the effective utilization of multispectral TM imagery. The critical elements of this system are illustrated in Figure 1 and consist of the following:

1) The TM sensor on the Landsat 5 spacecraft which is designed to obtain high spatial resolution measurements of Earth radiation in seven independent spectral bands.

2) The Tracking and Data Relay Satellite System (TDRSS) which can be used to relay TM data to a central ground receiving station located in White Sands, New Mexico. TDRSS will eventually consist of two geostationary satellites situated over the Pacific and Atlantic Oceans (respectively referred to as TDRS-West and TDRS-East). TDRSS will provide the capability to acquire TM data on a near global basis.

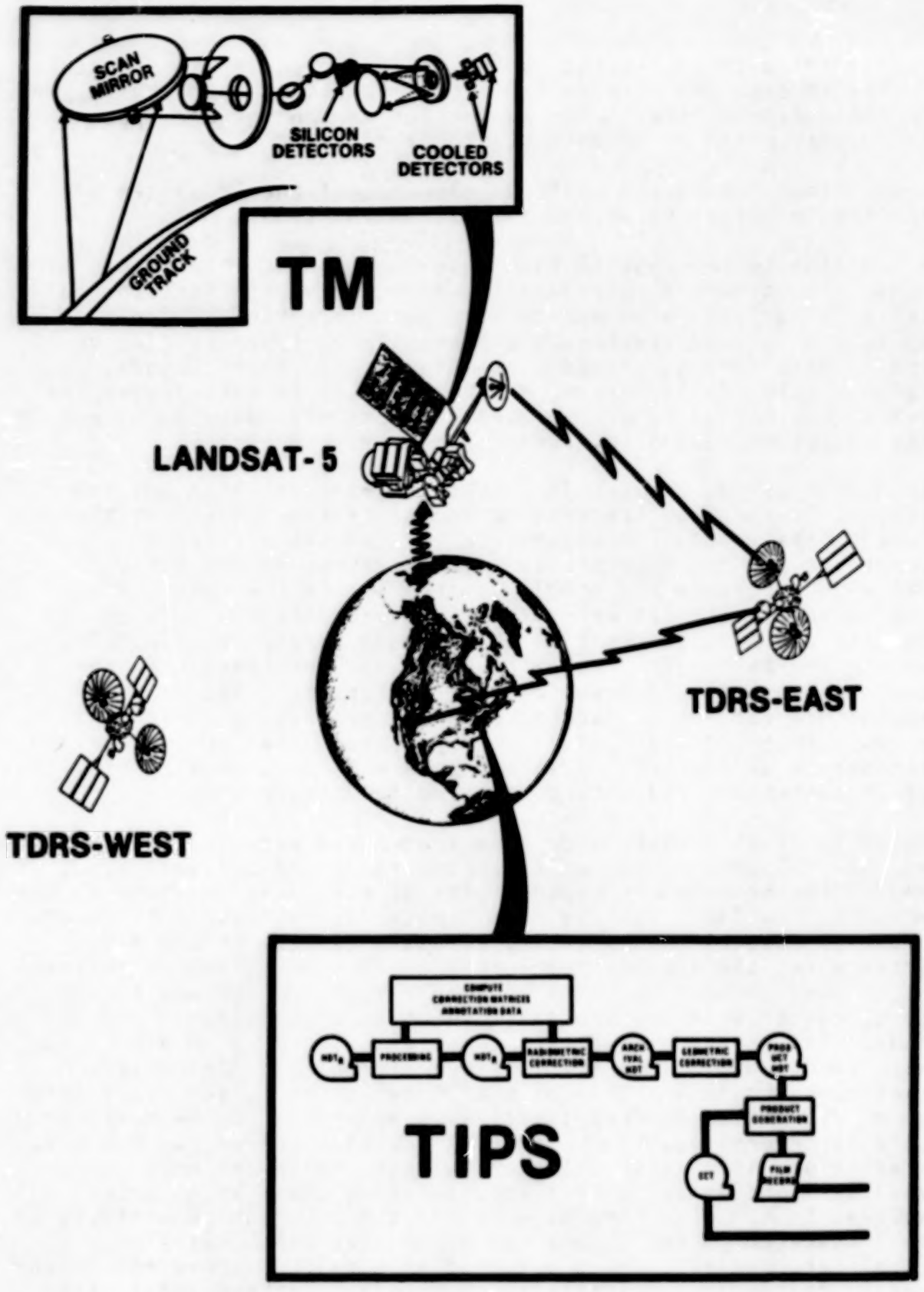


Figure 1. The critical elements of the Landsat TM system consist of the orbital TM sensor, the Tracking and Data Relay Satellite System (TDRSS), and the ground-based TM Image Processing System (TIPS). TDRS-West is currently scheduled for launch in the spring of 1985. The remaining elements of the TM system exist at the present time.

3) The TM Image Processing System (TIPS) which is used to reduce raw TM data and produce TM image products in both digital and photographic form. TIPS is located at the Goddard Space Flight Center in Greenbelt, Maryland.

As explained below, the critical elements of the TM system are expected to become fully operational during 1985.

In addition to the capabilities described above, TM data can be transmitted directly to ground-based receiving stations that are specially equipped with appropriate data reception equipment. Six foreign ground stations are currently equipped to receive TM data. These foreign ground stations are located in Canada, Sweden, Italy, India, Japan, and Brazil. It is anticipated that several additional foreign ground stations will develop direct TM data reception capabilities during the next two years.

Management of the Landsat TM system is shared by NASA and the National Oceanic and Atmospheric Administration (NOAA) at the present time. NOAA is responsible for Landsat spacecraft operations and the acquisition and processing of MSS data. NOAA also serves as the single point-of-contact within the U.S. Government for the delivery of Landsat products and services to domestic and foreign users of the overall Landsat system. The two and one-half years following the launch of Landsat 4 have been set aside for TM research and development. NASA is responsible for TM data acquisition and processing during this period. In addition, NASA is solely responsible for the use and maintenance of the TDRSS system. NOAA will assume responsibility for TM operations and data processing in January 1985.

The TM is significantly more complicated and more sophisticated than the MSS that served as the prime sensor on Landsats 1, 2, and 3. The measurement capabilities of these two instruments are summarized in Table 1. The TM possesses approximately twice the number of spectral bands that previously existed on the MSS. Furthermore, the spatial resolution of TM bands situated in the visible and reflective infrared spectrum is two and one-half times greater than the spatial resolution of comparable MSS bands. The TM and MSS were originally designed to obtain measurements over a comparable range of radiation intensity. However, the output signal of the TM detectors is quantized into one of 256 different grey levels as compared to the 64 level grey scale range employed in the digital quantization of raw MSS data. In addition, individual detectors within the TM are more sensitive to changes in incident radiation than the detectors employed in the MSS. Improvements in the inherent sensitivity of the TM detector elements and the range over which detector signals are quantized have resulted in a major improvement in the overall radiometric sensitivity of the TM. Further information concerning the design and measurement capabilities of the TM will be forwarded to prospective investigators submitting Letters of Intent to submit proposals in response to this Announcement.

TABLE 1 COMPARISON OF LANDSAT TM AND MSS MEASUREMENT CAPABILITIES

	THEMATIC MAPPER (TM)			MULTISPECTRAL SCANNER (MSS)		
• SPECTRAL RESOLUTION	BAND NUMBER	BANDWIDTH (MICRO-METERS)	RADIOMETRIC SENSITIVITY (NE$\Delta\rho$)*	BAND NUMBER	BANDWIDTH (MICRO-METERS)	RADIOMETRIC SENSITIVITY (NE$\Delta\rho$)*
	1	0.45 - 0.52	0.8	1	0.5 - 0.6	0.57
	2	0.53 - 0.61	0.5	2	0.6 - 0.7	0.57
	3	0.62 - 0.69	0.5	3	0.7 - 0.8	0.65
	4	0.78 - 0.91	0.5	4	0.8 - 1.1	0.70
	5	1.57 - 1.78	1.0			
	6	10.42 - 11.66	0.5K**			
	7	2.08 - 2.35	2.4			
• GROUND INSTANTANEOUS FIELD-OF-VIEW	30 METERS (BANDS 1-5 & 7) 120 METERS (BAND 6)			83 METERS (BANDS 1-4)		
• SIGNAL QUANTIZATION LEVEL	256 (8 BIT WORD)			64 (6 BIT WORD)		
• DATA RATE	85 MEGABITS/SEC			15 MEGABITS/SEC		

* RADIOMETRIC SENSITIVITY SPECIFIED AS THE NOISE EQUIVALENT DIFFERENCE IN SURFACE REFLECTANCE

** THERMAL BAND SENSITIVITY SPECIFIED AS THE NOISE EQUIVALENT DIFFERENCE IN APPARENT TEMPERATURE

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A. Thematic Mapper Sensor Performance

Current understanding of the orbital performance of the TM is based largely upon the analysis of Landsat 4 TM data. Although Landsat 5 is expected to be the primary source of TM data in the future, the results of earlier Landsat 4 TM evaluation studies are summarized here to provide prospective investigators with greater insight into the operating characteristics of the TM. Preliminary examination of Landsat 5 TM data indicates that there are no major differences between the orbital performance of the TM sensors on Landsats 4 and 5. It is currently anticipated that the radiometric and geometric quality of Landsat 5 TM imagery will be comparable to the quality of Landsat 4 TM data products described below. Investigators selected to participate in the TM Earth science research program will receive additional technical information concerning the operating characteristics of the Landsat 5 TM following their appointment to the TMSWG described in Section I.

The TM employs one hundred electronic detectors mounted on two physically separated focal planes to measure the intensity of Earth radiation. The instantaneous field-of-view (IFOV) of these detectors is swept across the ground track of the Landsat spacecraft by an oscillating mirror every 71.5 milliseconds. The response of each detector to the incident Earth radiation reflected by the scanning mirror is sampled electronically every 9.6 milliseconds and transmitted to the Earth in digital format. The quality of the data collected by the sensor is principally governed by the response of the individual detector elements to varying light levels, and the manner in which the IFOV of the TM detector array is translated across the Earth's surface as a function of time.

The orbital performance of the TM detectors is monitored on a continuous basis through the use of internal calibration lamps and a black body that serve as reference radiation standards. The focal plane detectors are exposed to these calibration standards during each complete cycle of the oscillating scan mirror. The response of the Landsat 4 TM detectors to these internal calibration standards has remained highly linear during the first year and a half of orbital operation. The internal calibration standards can be used to relate the orbital response of individual detectors to prelaunch calibration tests in which the same detectors were exposed to a series of light sources of known intensity. Procedures have been developed which enable an investigator to translate orbital DN (digital number) values recorded by the TM into quantitative measures of radiation intensity expressed in units of power per unit area per unit

solid angle per unit wavelength. Spectral radiance values inferred from Landsat 4 TM measurements are in good agreement with theoretical predictions of the radiation that reaches the sensor from the Earth's surface and the intervening atmospheric column. The output values of individual detectors are normally adjusted through a series of subsequent correction procedures that account for differences in the radiometric response of individual detectors in a single band and geometric distortion of the detector array's ground field-of-view. Studies performed to date have indicated that the radiometric fidelity of Landsat 4 TM imagery is quite good and that subtle variations in the radiometric characteristics of the Earth's surface are preserved through these various adjustment procedures. Residual radiometric variations (i.e., noise) in the response of individual detectors are typically on the order of 1-2 digital numbers or less.

The instantaneous ground projection of the TM detector array is critically dependent upon the motion and attitude of the Landsat spacecraft, external vibrations applied to the TM sensor, and the motion of the TM scan mirror. The ephemeris, attitude, and attitude displacement of the Landsat spacecraft are monitored continuously by the onboard computer and gyroscopes. A three-axis angular displacement sensor is mounted on the exterior of the TM to monitor external vibrations in the frequency range of 2-125 Hertz. In addition, the position of the scan mirror is clocked in a precise fashion during each scan cycle to monitor the sweep of the TM optical axis across the ground track. All of these measurements are included in the payload correction data that are digitally integrated in the TM data stream. These measurements are employed in determining the ground projection of the TM detector array at successive detector sampling intervals.

The geometric quality of Landsat 4 TM imagery equals or exceeds prelaunch specifications. Multispectral measurements obtained within separate spectral bands are currently being coregistered to within 0.1 picture elements (pixels) or less. Certain LIDQA investigators have reported that Landsat 4 TM data products can be used for purposes of planimetric mapping at a scale of 1:100,000. In fact, it has been reported that TM data acquired over areas of relatively low relief can be used for planimetric mapping at scales approaching 1:48,000. The TM sensor was designed to achieve scene-to-scene coregistration accuracies of 0.3 pixel or better 90% of the time, and scene-to-map coregistration accuracies of 0.5 pixel or better approximately 90% of the time. The evaluation of multitemporal and geodetic registration accuracy is still in progress at the present time. Prelaunch concern about the potential effects of high frequency spacecraft vibrations, commonly called jitter, on image quality has been eliminated by post launch analyses of Landsat 4 TM data. These vibrations are manifested in raw TM data as underlap or overlap in the sequential fields of view of individual detector

elements. These underlap/overlap effects have been observed to attain values of one to four IFOVs in raw TM data. They are routinely removed by geometric correction procedures that make use of onboard vibration measurements supplied by the TM angular displacement sensors.

8. Landsat 4 and 5 Operations

Landsat 4 was originally launched on July 16, 1982. It has experienced a series of technical problems that have severely curtailed TM data collection. The major problem restricting TM data collection at the present time is the availability of onboard electrical power. Landsat 4 carries four solar panels to produce the electrical power required for payload and spacecraft operations. Two of these panels have failed in orbit, and the continued operation of the remaining panels is uncertain. The power failure resulted from the mechanical disruption of electrical wiring in the power cables that are attached to the individual panels. The cause of the failure is thought to be thermal stress produced by the repetitive exposure of the spacecraft to direct sunlight as it orbits the Earth. The solar array on Landsat 4 was subsequently reoriented to reduce the thermal stress experienced by the power cables attached to the remaining panels. Unfortunately, the electrical power produced while the array is in this position is insufficient to operate the TM in a routine fashion. NOAA is prepared to reorient the solar array on an intermittent basis to collect TM imagery of selective areas.

Landsat 5 was successfully launched on March 1, 1984. Several of the subsystems onboard this spacecraft were modified to ensure that the problems encountered by Landsat 4 will not be experienced by Landsat 5. These changes include: the modification of electronic components employed in the onboard computer command unit, the partial redesign and modification of electronic components in the X-Band transmitter used for direct transmission of TM data to ground receiving stations, and the redesign of the electrical power cable that is attached to the rear of the spacecraft's solar panels. The orbital checkout of Landsat 5 and its sensor payload was completed during April 1984. Both the Landsat 5 TM sensor and the Landsat 5 spacecraft are operating nominally at the present time.

Landsats 4 and 5 are designed to travel around the Earth in near circular, sun-synchronous orbits inclined 98.2^{0} with respect to the equator. Consequently, TM data can be collected anywhere between 82^{0} North and South latitude. Because these spacecraft are in sun-synchronous orbits, the local time beneath each spacecraft remains approximately constant. Each spacecraft crosses the daytime equator at roughly 9:45 a.m. local time, and the nighttime equator at roughly 9:45 p.m. local time. Earth observation sensors on earlier Landsat spacecraft were used solely to measure the intensity of reflected solar radiation on the daytime side of the Earth. TM Band 6 situated in the thermal infrared portion of the spectrum can be used to measure the intensity of thermal radiation emitted from the Earth's surface under both daytime and nighttime conditions.

The TM is designed to collect data over a ground swath of 185 kilometers from a nominal altitude of 705 kilometers above the Earth's surface. At this altitude, TM ground swaths acquired on consecutive orbital passes of each spacecraft are separated by a distance of 2,750 kilometers at the equator. Prospective investigators wishing to conduct repetitive observations of extended areas should realize that there is a significant time interval between the collection of TM imagery along adjacent ground swaths. Coverage of an area to the west of a previously acquired scene can be obtained seven days after the previous scene was originally collected. Similarly, there is a nine-day interval between the collection of imagery along a particular ground swath and the adjacent swath lying to the east. At the equator, adjacent swaths of TM imagery overlap at their eastern and western edges by approximately 14 kilometers. The degree of sidelap between adjacent swaths increases at higher latitudes (e.g., it is 34 kilometers at 40^{o} North and South latitude).

Landsat 5 has been placed in an orbit with an equatorial node crossing that is displaced with respect to the orbit of the Landsat 4 spacecraft. In principle, this difference in orbital nodes will enable the two satellites to collect TM imagery of specific areas every 8 days. As indicated above, however, it is difficult to forecast the orbital lifetime of the Landsat 4 spacecraft in light of the solar panel failures that have occurred in the past. If Landsat 5 serves as the sole source of TM data in the future, repetitive observations of specific test site areas could be conducted every 16 days under cloud-free conditions.

C. Tracking and Data Relay Satellite System (TDRSS)

TDRSS is currently being deployed to provide a means of communicating with Earth-orbiting spacecraft on a global basis in real time. It will ultimately consist of two communications satellites situated in geostationary orbits above the Earth's equator. These spacecraft are commonly referred to as TDRS-East and TDRS-West. They will be located above the Atlantic and Pacific Oceans at 41^{o} and 171^{o} West longitude, respectively.

TDRS-East was launched in April 1983, and it is currently in orbit. Recent problems encountered in transmitting data from the ground to orbiting spacecraft through TDRS-East have no impact upon the use of this satellite for TM data collection. The launch of TDRS-West has been delayed due to problems encountered with the upper stage rocket that is used to boost the TDRS spacecraft into geostationary orbit. TDRS-West is now scheduled for launch in the spring of 1985. Approximately 90-120 days will be required to evaluate the post launch performance of TDRS-West and certify the satellite for operational use. It is currently anticipated that the full TDRS system will be available for TM data collection sometime during the summer of 1985.

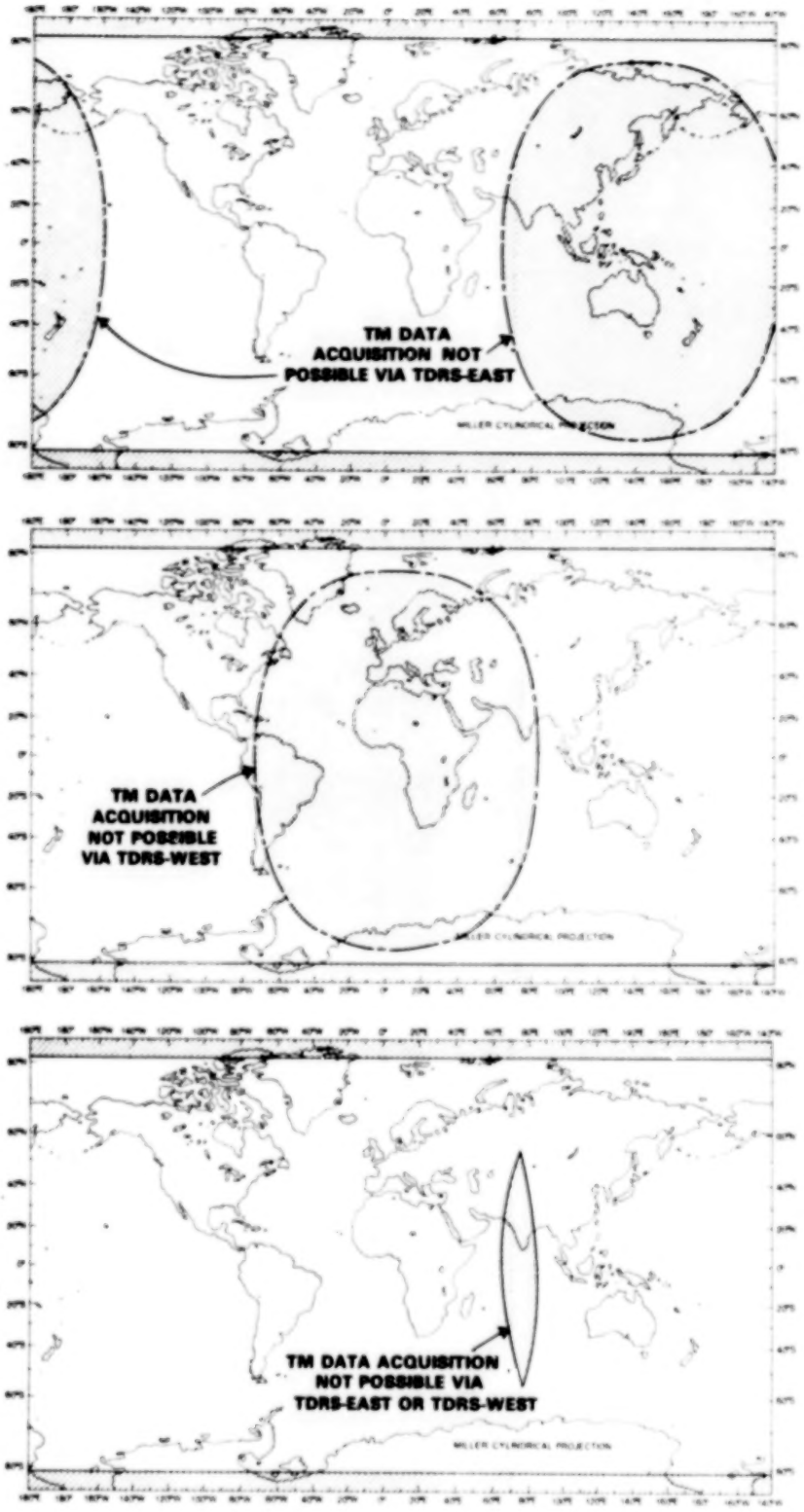

FIGURE 2 SHADED AREAS REPRESENT REGIONS WHERE TM IMAGERY CANNOT BE ACQUIRED VIA ONE OR BOTH OF THE TDRS SPACECRAFT

As shown in Figure 2, TM data can be acquired via TDRSS almost anywhere in the world. Landsats 4 and 5 pass out of view of both TDRS spacecraft over portions of Tibet, India, and the Indian Ocean. TM data cannot be acquired via TDRSS over these regions.

TDRSS will be used in conjunction with North American ground stations to acquire the TM imagery required by the investigators participating in this data analysis program. Prospective investigators may wish to employ TM data that have been acquired and processed by foreign Landsat ground stations. Under these circumstances, the investigator will assume all responsibility for obtaining the TM data required to conduct the proposed investigation (see Section VI for details).

D. Thematic Mapper Image Processing System (TIPS)

TIPS is a computer facility that reduces raw TM data and produces TM data products in both digital and photographic formats. It is located at the Goddard Space Flight Center in Greenbelt, Maryland, and consists of two identical data processing subsystems. The central processing unit of each subsystem contains a minicomputer interfaced to an advanced, high speed array processor. TIPS is currently processing TM data for purposes of research and development at a comparatively low rate. TIPS is scheduled to reduce TM data at a considerably higher rate on an operational basis in January 1985 when NOAA assumes responsibility for managing the system.

TM data enters TIPS in digital form. Electronic signals received from the TM focal plane detectors are combined with various types of payload correction data on a high density magnetic tape known as an HDT-RT (high density tape-raw tape). Radiometric corrections are applied to this raw data to account for variations in the response (i.e. gain and bias values) of individual detectors within each spectral band. The data product resulting from these radiometric corrections is known as an HDT-AT (high density tape-archival tape). In the final step of the correction process, the field-of-view of the individual detectors is registered with respect to a standard cartographic grid; and a cubic convolution resampling procedure is used to assign digital number (DN) values to evenly spaced grid points. The field-of-view of the TM detector arrays can be registered to several different cartographic projections including the Universal Transverse Mercator, Space Oblique Mercator, and Polar Stereographic systems. The data product resulting from this geometric correction procedure is known as an HDT-PT (high density tape - processed tape). The high density data tapes produced by TIPS contain 28 separate recording tracks with a packing density of 33,300 bits per inch on each track. All of these data products can be transcribed to lower density magnetic tapes that are computer compatible. Standard computer compatible tapes (CCT's) produced by TIPS contain nine tracks with a packing density of 6,250 bits per inch.

Photographic data products are generated from HDT-PT data employing a laser beam recorder. First generation film positives are shipped to the EROS Data Center where they are reproduced for public distribution. Standard TM photographic products provide information concerning the contrast stretch that was applied to DN values in each spectral band during the film generation process. The contrast enhancement procedures currently being employed in generating film products are standardized and they are applied to all photographic products without regard for scene composition or illumination conditions. Alternative enhancement procedures are being studied during the TIPS R&D phase that would involve the use of scene-dependent variables such as spectral albedo or solar elevation angle in redistributing the observed range of DN values over a suitable portion of the image grey scale available in the photographic products.

TIPS is currently reducing 12 TM scenes per day to HDT-AT and HDT-PT formats. Photographic products for each of these scenes are also being generated on a daily basis. Two of the twelve scenes processed each day are transcribed onto CCT's and they are available as CCT-PT's (computer compatible tape - processed tape).

TIPS data reduction capabilities are scheduled to expand in January 1985. At that time, TIPS will have the capability to reduce 100 TM scenes to HDT-AT format per day. In addition, the system will have the capacity to process 50 of these 100 scenes to HDT-PT format on a daily basis. It is currently planned that 10 of the HDT-PT's produced each day will be transcribed into CCT-PT's. The higher rate of TM data production that will be achieved in January 1985 is considered essential to satisfy the data requirements of the investigators participating in the TM research program described in this Announcement.

V. PROPOSAL OPPORTUNITY PERIOD

All proposals submitted in response to this Announcement are due at NASA Headquarters by the close of business (4:30 p.m. EST) on October 22, 1984. NASA reserves the right to consider proposals received after this deadline if such an action is judged to be in the interest of the U.S. Government. A complete proposal schedule is given in Section IX.

VI. REQUIREMENTS AND CONSTRAINTS

It is currently anticipated that the ability to acquire TM data on a near-global basis and process such data in a timely fashion will be fully realized during 1985. The Landsat 5 spacecraft and associated TM sensor are fully functional at the present time. The ground-based TIPS is scheduled to achieve an image production capability of 10 TM scenes in digital, computer compatible P-tape format per day in January 1985. This capability is required to provide data to investigators in a timely fashion. The TDRS launched in April 1983 is currently capable of relaying Landsat 5 TM data to a central ground receiving station in White Sands, New Mexico. A second TDRS spacecraft (TDRS-West) is currently scheduled for launch in the spring of 1985. A 90-120 day checkout period is required following the launch of this satellite to certify its operational readiness. Acquisition of Landsat 5 TM imagery on a near-global basis via TDRS-East and TDRS-West should become feasible by mid-1985 if TDRS-West is launched on schedule. Proposals should present a schedule of data acquisition and analysis activities that is commensurate with the expected availability of these space and ground-based resources.

Unless otherwise notified by a prospective investigator, NASA will assume all responsibility for providing TM data to the domestic and foreign scientists selected to participate in this research program. Prospective investigators may wish to make use of TM data that have been acquired and processed by foreign Landsat ground receiving stations. Under these circumstances, the investigator will assume all responsibility for developing the contractual arrangements with the foreign ground station that are required to obtain such data. All proposers should clearly identify the anticipated source of the TM data they intend to employ in their investigation. All proposers should specify the total amount of TM data required by their investigation, the form in which it is to be delivered, and the desired timetable for data acquisition and receipt.

The TDRS System (TDRSS) will be the sole means available to NASA for acquiring TM imagery of overseas areas (i.e., areas situated outside of North America). TM imagery cannot be acquired via TDRSS over portions of Tibet, India, and the Indian Ocean (see Figure 2). Therefore, NASA is not prepared to consider proposals that seek to conduct TM related research within these areas unless the prospective investigator has made alternative arrangements for TM data acquisition with representatives of the Indian ground receiving station (see the preceding paragraph).

In principle, it may be possible to employ the TM sensors on Landsats 4 and 5 in a combined fashion to acquire imagery of specific test site areas every eight days. The ability to conduct repetitive observations with this temporal frequency is critically dependent upon the continued operation of the TM on Landsat 4. It is difficult to forecast the lifetime of the Landsat 4 spacecraft or the constraints that may be imposed on the use of the Landsat 4 TM due to the technical problems that have been encountered during the first year of Landsat 4 operations. Proposals that wish to employ repetitive TM observations to study dynamic surface phenomena should clearly distinguish between the anticipated results that can potentially be achieved using one or two spacecraft for TM data acquisition.

TM observational data are expected to play a central and substantial role in the proposals submitted in response to this Announcement. Furthermore, it is anticipated that the proposer's ability to achieve the anticipated results of his or her investigation is contingent upon the successful analysis and interpretation of orbital TM imagery. Prospective investigators may wish to conduct ground-based field measurements, laboratory studies, theoretical analyses, and/or modeling studies in conjunction with their proposed TM data analysis activities. Prospective investigators may also wish to analyze other types of space-acquired data in conjunction with their analysis of TM imagery. NASA is prepared to sponsor these various activities to achieve the broader scientific objectives of meritorious investigations. However, to be responsive to the objectives of this opportunity, prospective investigators should clearly indicate the relationship of these other activities to the analysis and interpretation of TM data. NASA is not prepared to sponsor the acquisition or development of major pieces of instrumentation under the auspices of this data analysis program.

The technical progress and accomplishments of approved investigations will be monitored by the Goddard Space Flight Center (GSFC). All selected investigators will be required to submit semiannual progress reports to GSFC describing the current status of their project and a final report at the end of the investigation period. Investigators are expected to make available to NASA all techniques, methods of analysis, and results developed over the course of their investigation (see Appendix A for details).

VII. PROPOSAL SUBMISSION INSTRUCTIONS

A. Letter of Intent to Propose

The Landsat Program Scientist at NASA Headquarters is Dr. Mark Settle. Individuals interested in submitting a proposal in response to this Announcement should send a one-page letter notifying NASA of their intent to propose to:

Dr. Mark Settle
c/o Code EPM (Ref. AO-OSSA-3-84)
National Aeronautics and Space Administration
Washington, DC 20546

When the proposer is from any country other than the U.S.A., the Letter of Intent should be sent to the above address with a copy to:

Ms. Lynn Cline
Thematic Mapper Research Program (AO-OSSA-3-84)
International Affairs Division (Code ' .D)
National Aeronautics and Space Administration
Washington, DC 20546
U.S.A. TELEX No. 89530

Letters of Intent should include the following information:

- Name, address, and telephone number of the Principal Investigator,
- Name and address of the Principal Investigator's home institution, and
- Tentative title of the intended investigation.

Letters of Intent should be received at NASA Headquarters on or before September 28, 1984. Material in these letters is for information only and is not binding on the signatories. Additional information can be obtained from Dr. Mark Settle at the above address or at telephone number (202) 453-1720. All individuals submitting a Letter of Intent will receive additional information concerning the scope of this research program and the measurement capabilities of the TM.

B. Proposal Preparation Procedures

A uniform proposal format will be required to aid in proposal evaluation and to facilitate comparative analysis. Detailed instructions concerning the desired contents and organization of TM research proposals are presented in Appendix B of this Announcement. All proposals should contain a technical plan describing the technical aspects of the investigation and a management/cost plan describing how the project will be implemented. Page restrictions will be applied to the length of the technical plan and investigator biographies presented in the proposal. These page restrictions are specified in Appendix B, and they will be strictly enforced. All proposals must be submitted in English. Foreign proposals must be accompanied by a letter of endorsement from a foreign sponsoring agency (see Appendix B).

Each proposal should identify a single individual as the Principal Investigator who will lead the investigation and serve on the TMSWG. Individuals who assist a Principal Investigator in data analysis activities will be considered to be Coinvestigators. The roles and responsibilities of these individuals should be clearly defined within the proposal.

Technical data of a proprietary nature contained in any proposal will be used by NASA for evaluation purposes only. Special procedures described in Appendix A of this document should be used to specify those sections of a proposal that constitute a trade secret under law. It is NASA policy to protect proprietary data and information from public disclosure.

C. Proposal Submission

Fifteen copies of each proposal should be submitted to NASA. Five of these copies should include the management/cost plan, and the remaining ten should consist of the technical plan alone. At least one complete copy of the proposal must be signed by an institutional official authorized to certify institutional support, sponsorship of the investigation, and the management and financial aspects of the proposed project. Proposals originating from within the United States should be sent to:

National Aeronautics and Space Administration
Office of Space Science and Applications
Attn: Code EPM (AO No. OSSA-3-84)
Washington, DC 20546

Foreign proposals should be mailed to:

National Aeronautics and Space Administration
International Affairs Division
Attn: Code LID (AO No. OSSA-3-84)
Washington, DC 20546

VIII. PROPOSAL EVALUATION, SELECTION, AND IMPLEMENTATION

A. Evaluation and Selection Procedures

All proposals received in response to this Announcement will be initially screened by the Landsat Program Scientist and the Landsat Project Scientist to determine their general relevance to the objectives stated in Section II. Those proposals considered to be unresponsive to the stated objectives of this Announcement will be returned to their authors immediately with a written explanation of this determination. Such proposals will not be considered further by NASA. Those proposals considered to be responsive to the Announcement objectives will subsequently be reviewed by a technical panel composed of individuals with widely recognized expertise in remote sensing and various Earth science disciplines. The purpose of this review is to evaluate the scientific merit and technical feasibility of the proposed investigation. Those proposals considered to be meritorious and feasible in principle will be further evaluated by the Landsat Project Office at the Goddard Space Flight Center to determine the feasibility of obtaining the TM data required by the proposed investigation. An ad hoc subcommittee of the Space Science and Applications Steering Committee will categorize all proposals on the basis of these reviews in accordance with standard NASA procedures as set forth in NASA Handbook NHB 8030.6A. Proposals which do not request NASA funds for data analysis activities will be subject to the same review and evaluation procedures as those proposals requiring financial support.

The procedures, documentation, and results of the proposal evaluation process will be reviewed by the full Space Science and Applications Steering Committee (SSASC). Final decisions concerning the acceptance of individual proposals will be made by the Associate Administrator for Space Science and Application based upon the recommendations of the SSASC. These decisions will take into consideration the balance between different scientific disciplines within the overall program of investigations, the availability of funds and mission-related resources, and the relevance of proposed investigations to ongoing NASA programs.

B. Evaluation Criteria

The fundamental goal of the investigation acquisition process is to identify unique ideas and capabilities which best suit the overall scientific and technological objectives of NASA. The following criteria, listed in descending order of importance, will be used in evaluating individual proposals.

(1) The relevance of the proposed investigation to the specific opportunity and the objectives cited above (Section II).

(2) The scientific and technical merit of the investigation, including the significance of the investigation's anticipated results and the degree of innovation displayed by the proposal.

(3) The technical feasibility of conducting the investigation and achieving positive results during the lifetime of the study, with special emphasis on the adequacy and practicality of the experimental plan presented in the proposal.

(4) The competence and relevant experience of the Principal Investigator and any collaborators as an indication of their ability to carry the investigation through to a successful conclusion.

(5) The reputation and interest of the Principal Investigator's institution, as measured by the willingness of the institution to provide the necessary support to insure that the investigation can be completed satisfactorily.

In addition to the criteria listed above, cost and management factors will be separately considered in all selections. Management aspects include the time and attention the Principal Investigator plans to devote personally to the investigation. NASA may desire to select only a portion of a proposer's investigation, in which case the investigator will be given the opportunity to accept or decline such partial acceptance.

C. Implementation

Individuals responding to this Announcement will be notified of the outcome of the proposal selection process by NASA Headquarters. It is currently expected that official notifications of acceptance or rejection will be issued in January 1985. Selected investigators will subsequently be contacted by a representative of the Goddard Space Flight Center who will be authorized to discuss the specific terms under which the investigation will be implemented.

IX. SCHEDULE

Letter of Intent to propose should be received by	September 28, 1984
Proposals due at NASA Headquarters by 4:30 PM EDT	October 22, 1984
Announcement of Selections	January 1985

The Landsat program has matured considerably during the past twelve years. It is NASA's intention to broaden the scope of Landsat data analysis activities even further by exploiting the Earth observation capabilities of the Landsat TM to learn more about the physical characteristics and behavior of our planet. I invite you to participate in this innovative and exciting program of research.

B. I. Edelson
Associate Administration for
Space Science and Applications

APPENDIX A

GENERAL INSTRUCTIONS AND PROVISIONS

I. Instrumentation and/or Ground Equipment

By submitting a proposal, the investigator and his institution agree that NASA has the option to accept all or part of the offeror's plan to provide the instrumentation or ground support equipment required for the investigation. NASA may furnish or obtain such instrumentation or equipment from any other source as determined by the selecting official. NASA reserves the right to require use of Government instrumentation or property to achieve the objectives of the proposed investigation if it is in the Government's interest to do so.

II. Tentative Selections, Phased Development, Partial Selections, and Participation with Others

By submitting a proposal, the investigator and his institution agree that NASA has the option to make a tentative selection pending a successful feasibility or definition study of the proposed investigation. Furthermore, NASA has the option to contract in phases for implementation of a proposed investigation and to discontinue the development of an investigative effort at the completion of any phase. The investigator should also understand that NASA may desire to select only a portion of the proposed investigation. In cases in which two or more proposals address similar topical problems and/or adopt similar approaches to TM data analysis, NASA may desire joint participation on the part of two or more proposers in a single data analysis project. Where joint participation with other investigators is agreed to, a single individual will be designated as the leader or contact point for the investigator group.

III. Selection Without Discussion or After Limited Discussion

The U.S. Government reserves the right to reject any or all proposals received in response to this Announcement when such action shall be considered in the best interest of the Government. Notice is also given of the possibility that any selection may be made without discussion or after limited discussion. It is, therefore, emphasized that all proposals should be submitted initially on the most favorable terms that the offeror can submit.

IV. Foreign Proposals

Proposals for participation by individuals outside the U.S. should be submitted in the same format (excluding cost plans) as U.S. proposals. They should be typewritten in English. Foreign proposers must have their proposal reviewed and endorsed by an appropriate foreign sponsoring agency. Endorsed proposals should be forwarded to NASA in sufficient time to arrive before the deadline indicated under Section IV of the Announcement. Foreign proposals received by NASA that are not accompanied by a letter of endorsement will be returned to their authors without further consideration. A "Letter of Intent" to propose should be sent directly to the office designated in the Announcement with a copy sent to NASA's International Affairs Division. All other correspondence (including proposals and endorsements) from foreign proposers and organizations should be sent to:

National Aeronautics and Space Administration
International Affairs Division
Code LID (A.O. No. OSSA-3-84)
Washington, DC 20546
U.S.A.

Foreign proposals will be subject to the same evaluation and selection procedures applied to proposals originating within the U.S. Should a foreign proposal be selected, NASA will arrange with the sponsoring foreign agency for the proposed participation on a no-exchange-of-funds basis, in which NASA and the sponsoring agency will each bear the cost of discharging its respective responsibilities including travel and subsistence for its own personnel.

V. Treatment of Proposal Data

A. Commercial and Financial Data

1. It is NASA's policy to use commercial and financial data included in proposals for evaluation purposes only. This policy does not require that this kind of proposal data bear the "Notice" described below.

2. Where it is the practice of an offeror or his proposed subcontractor to treat certain commercial and financial data as a trade secret and such data is protectible as a trade secret under law he may apply the "Notice" of paragraph (B) below to those portions of a proposal to be maintained as a trade secret.

3. In any event, commercial and financial data submitted to NASA in a proposal will be protected to the extent permitted under the law either as a properly noticed trade secret or as commercial or financial information received from a person and considered confidential or privileged.

B. Technical Data

It is NASA's policy to use the technical data contained in any proposal submitted in response to this Announcement for evaluation purposes only. Where any such technical data constitutes a trade secret under the law and the offeror, or his potential subcontractor, desires to maintain trade secret rights in such technical data, the following "Notice" must be affixed to the cover sheet of the proposal specifying the pages of the proposal which contain trade secrets to be restricted in accordance with the conditions of the "Notice." It is NASA policy to protect technical data labelled in this fashion as a trade secret. NASA assumes no liability for use or disclosure of any proposal technical data to which the "Notice" has not been applied.

NOTICE

Data on page(s) ..... of this proposal constitute a trade secret. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes. In the event a contract is awarded on this proposal, the Government may obtain in the contract additional rights to use and disclose this data.

VI. Status of Cost Proposals (U.S. Proposals Only)

The investigator's institution agrees that the cost proposal submitted in response to the Announcement is for proposal evaluation and selection purposes, and that following selection and during negotiations leading to a definitive contract, the institution will be required to resubmit or execute a DD Form 633 (Contract Pricing Proposal) as well as submitting all certifications and representations required by law and regulation.

VII. Late Proposals

NASA reserves the right to consider proposals or proposal modifications received after the submission deadline but prior to the date of selection should such an action be in the interest of the U.S. Government.

VIII. Disclosure of Proposals Outside the U.S. Government

NASA may wish to obtain assistance outside the U.S. Government in evaluating the technical or scientific aspects of individual proposals. Special arrangements will be established for the appropriate handling of proposal information by outside reviewers. If the investigator or his institution wishes to preclude NASA from employing outside reviewers, the investigator or his institution should so indicate in a cover letter accompanying the proposal. By submitting a proposal without such a letter, the investigator and his institution implicitly agree that NASA may have the proposal reviewed by outside specialists

who possess recognized expertise in terrestrial remote sensing and various Earth science disciplines. If a proposer objects to the use of outside experts for purposes of proposal evaluation, NASA may be unable to consider the proposed investigation for inclusion in the TM research program described in this Announcement.

IX. Equal Opportunity (U.S. Proposals Only)

By submitting a proposal, the investigator and his institution agree to accept the below clause in any resulting contract:

EQUAL OPPORTUNITY (JUNE 1973)

During the performance of this contract, the contractor agrees as follows:

(1) The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The contractor will take affirmative action to ensure that applicants are employed and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to, the following: Employment, upgrading, demotion or transfer, recruitment advertising; layoffs or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the contracting officer setting forth the provisions of this nondiscrimination clause.

(2) The contractor will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(3) The contractor will send to each labor union or representative of workers, with which he has a collective bargaining agreement or other contract or understanding, a notice to be provided by the agency contracting officer, advising the labor union or workers' representative of the contractor's commitments under this nondiscrimination clause and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(5) The contractor will furnish all information and reports required by Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and by the rules, regulations, and orders of the Secretary of Labor or pursuant thereto and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the contractor's noncompliance with the Equal Opportunity clause of this contract or with any of the said rules, regulations, or orders, this contract may be cancelled, terminated, or suspended in whole or in part; and the Contractor may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967; and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, or by rule, regulation, or order of the Secretary of Labor or as otherwise provided by law.

(7) The contractor will include the provisions of Paragraph (1) through (7) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, so that such provisions will be binding upon each subcontractor or vendor. The contractor will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions including sanctions for noncompliance; provided, however, that in the event the contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

X. Invention and Data Rights

The following provisions concerning invention and data rights will be applicable to any contract resulting form a selection under this Announcement.

(1) In instances where NASA totally or partially funds an investigation under a NASA contract, NASA is required by law to take title to inventions which may result from the work performed under the contract. The contractor would be granted a royalty-free license to practice the invention. The contractor, however, could petition for waiver of such title in accordance with NASA Patent Waiver Regulations 14 C.F.R. 1245.1, whereupon the Agency would give favorable consideration towards waiving title to the invention to the contractor subject to the reservation by the Government of a royalty-free license. As a general rule, the contract provides that NASA and the contractor can use and disclose, without restrictions, the data generated under the contract.

(2) In instances where a joint project is undertaken, i.e., the investigator furnishes the investigation without charge to NASA and no transfer of funds takes place, NASA will obtain a royalty-free license to practice for U.S. Governmental purposes any inventions resulting from the investigation together with the right to use and disclose the resulting data for U.S. Governmental purposes.

APPENDIX B

GUIDELINES FOR PROPOSAL PREPARATION

The following guidelines apply to the format of proposals prepared in response to this Annoucement. The proposal format outlined below is merely a guide for the prospective proposer. Strict adherence to this format is not absolutely necessary. However, proposals should provide information concerning all of the items described below and as otherwise specified in this Announcement. In addition, the proposal length limitations described below will be strictly enforced.

1. COVER LETTER

A letter or cover page should be forwarded with the proposal. It should be signed by the investigator and an official of the investigator's organization who is authorized to commit the organization to the contents of the proposal.

2. IDENTIFYING INFORMATION

The proposal should contain a short descriptive title for the investigation, the names of all investigators, the name of the organization or institution, the full name of the principal investigator, his address with zip code, and his telephone number.

3. TABLE OF CONTENTS

The proposal should contain a table of contents.

SECTION I--INVESTIGATION AND TECHNICAL PLAN

1. INVESTIGATION AND TECHNICAL PLAN

The investigation and technical plan generally will contain the following information.

a. Summary. A simple, concise statement about the investigation, its conduct, and the anticipated results. This summary should not exceed two single-spaced, typewritten pages.

b. Experimental Objectives. It is presumed that the investigation will seek to test or verify one or more specific scientific hypotheses. These hypotheses should be stated in a clear and concise fashion.

c. Technical Background. The conceptual and technical feasibility of the investigation should be established through references to current understanding, theories, and technical capabilities in relevant disciplinary fields. Proposals should cite earlier studies that provide the conceptual foundation or basis for the proposed investigation. In addition, the proposal should cite earlier remote sensing studies that established the data analysis methods or information extraction procedures to be used in the proposed investigation, if applicable.

d. Experimental Plan. The overall methodology of the investigation should be presented in some detail. The proposal should specifically identify the total amount of TM data required by the investigation, the form in which it is to be delivered to the principal investigator, and the desired timetable for data acquisition and delivery. Ancillary types of data to be employed in the analysis and interpretation of TM imagery should be clearly identified. Sources of ancillary data should be described along with the procedures that will be used to collect and reduce ancillary data sets. There should be a clear and logical connection between the data that will be employed by the investigation, the information that will be extracted or inferred from this data, and the manner in which such information will be used in addressing the stated objectives of the investigation. The chronological sequence of data collection, analysis, and interpretation activities envisioned by the investigation should be explicitly described. This sequence of events will be carefully evaluated to ensure that the study can be successfully completed during the proposed lifetime of the investigation. In cases where detailed studies of particular test site areas will be conducted, the proposal should explicitly define the factors that were considered in test site selection.

e. Anticipated Results. To the extent that it is feasible, the expected outcome of the investigation should be described in the proposal.

f. Significance of the Investigation. The significance of the proposed study should be defined in terms of its relationship to earlier studies of a similar nature and/or the implications of the anticipated results. The proposal should attempt to characterize the relative degree of innovation associated with the objectives or approach of the proposed study. In addition, the proposal should attempt to characterize the importance of the anticipated results in relation to the current state of knowledge within particular disciplinary fields. The extent to which the anticipated results will influence the definition and conduct of future research projects on similar or related topics should be discussed in the proposal.

The technical plan should not exceed twenty (20) single spaced pages of printed text, excluding illustrations, tables, references, bibliographies, and biographical information. Information concerning the education, training, and relevant experience of the investigators involved in the proposed study should be provided on separate sheets attached to the technical plan. Biographical information of this nature should be limited to two pages or less for each investigator who will play a substantial role in the investigation. Proposers who wish to provide evidence of their experience and knowledgeability in particular disciplinary fields are encouraged to cite relevant publications they have authored in the general scientific literature. References to earlier publications should be limited to major publications that are directly relevant to the proposed investigation. These citations should be included within the two pages allotted to each investigator for biographical information. Proposers should not include lengthy publication bibliographies or copies of specific publications in their proposal.

Information concerning specialized equipment or facilities that will be used during the course of the investigation should not be presented in the technical plan. Information of this nature should be included in the management and cost plans described below.

It is anticipated that a large number of proposals will be received by NASA in response to this Announcement. To expedite the proposal evaluation process and assure fairness to all proposers, the length restrictions described above will be strictly enforced. If a prospective investigator fails to observe the restrictions on proposal length cited above, NASA reserves the right to return the proposal to the proposer upon receipt without further review or evaluation.

SECTION II--MANAGEMENT PLAN AND COST PLAN

The management and cost plans should be prepared in a combined fashion and reproduced as a physically separate document that can accompany the investigation and technical plans described above. The investigation/technical plans and the management/cost plans will be reviewed independently during the various stages of the proposal evaluation process described in Section VIII.

A. MANAGEMENT PLAN

The management plan should summarize the management approach and the facilities and equipment required. Additional guidelines applicable to non-U.S. proposers are contained herein.

1. MANAGEMENT

a. The management plan sets forth the investigator's approach for efficiently managing the work, the recognition of essential management functions, and the effective overall integration of these functions.

b. The management plan gives insight into the organization proposed for the work, including the internal operations and lines of authority with delegations, together with internal interfaces and relationships with NASA, major subcontractors, and associated investigators. Likewise, the management plan usually reflects various schedules necessary for the logical and timely pursuit of the work accompanied by a description of the Principal Investigator's work plan and the responsibilities of the scientific collaborators (if any).

c. The planned participation by small/disadvantaged business in any subcontracting for investigative support functions should be indicated.

2. FACILITIES AND EQUIPMENT

All major facilities and equipment essential to the proposed investigation should be indicated, including those of the investigator's proposed subcontractors and those of NASA and other U.S. Government agencies. Existing equipment should be explicitly differentiated from facilities that will be developed to implement the investigation. Procurement schedules and lead times for the acquisition and installation of new equipment and facilities should also be indicated.

3. ADDITIONAL GUIDELINES APPLICABLE TO NON-U.S. PROPOSERS ONLY

The following guidelines are established for foreign responses to NASA's Announcement of Opportunity. These guidelines indicate the appropriate measures to be taken by foreign proposers, prospective foreign sponsoring agencies, and NASA leading to the selection of a proposal and execution of appropriate arrangements. They include the following:

a. With respect to the "Letter of Intent" to propose, prospective foreign proposers should write directly to the NASA official designated in the Announcement and send a copy of this notice to the International Affairs Division, Code LID (A.O. No. OSSA-3-84), Washington, DC 20546, U.S.A.

b. Proposals will be submitted in accordance with these NASA "Guidelines for Proposal Preparation." Proposals should be typewritten in English.

c. Persons planning to submit a proposal should arrange with an appropriate foreign governmental agency for a review and endorsement of the proposed activity. Such endorsement by a foreign organization indicates:

    1) The proposal merits careful consideration by NASA.

    2) If the proposal is selected, sufficient funds will be available to undertake the activity envisioned.

d. Proposals (along with the requested number of copies) and letters of endorsement from the foreign governmental agency should be forwarded to NASA in time to arrive before the deadline established in this Announcement of Opportunity. These documents should be sent to:

    National Aeronautics and Space Administration
    International Affairs Division
    Code LID (A.O. No. OSSA-3-84)
    Washington, DC 20546
    U.S.A.

e. All proposals should be received on or before the established closing date. Those proposals received after the closing date will be treated in accordance with NASA's provisions for late proposals. Sponsoring agencies may, in exceptional situations, forward a proposal directly to the above address if review and endorsement is not possible before the announced closing date. In such cases, NASA should be advised when a decision on endorsement can be expected.

f. Successful and unsuccessful proposers will be contacted directly by the NASA program office coordinating this Announcement of Opportunity. Copies of these letters will be sent to the sponsoring governmental agency.

g. NASA's International Affairs Division will then begin making the necessary arrangements to provide for the selectee's participation in the program. Depending on the nature and extent of the proposed cooperation, these arrangements may entail:

    1) A letter of notification by NASA.

    2) An exchange of letters between NASA and the sponsoring foreign governmental agency.

    3) An agreement between NASA and the sponsoring foreign governmental agency defining the provisions for participation of the foreign investigator in the program.

B. COST PLAN (U.S. Investigations Only)

The cost plan should summarize the total investigation cost by major categories of cost as well as by function. In addition, proposals for multiyear investigations should present cost plans for each year of the proposed project in accordance with the categories defined below.

1. COST CATEGORIES

The categories of cost should include the following:

a. Direct Labor. List by labor category, with man-hours and rates for each. Provide actual salaries of all personnel and the percentage of time each individual will devote to the effort.

b. Overhead. Include indirect costs which, because of their incurrence for common or joint objectives, are not readily subject to treatment as a direct cost. Usually, this is in the form of a percentage of the direct labor costs.

c. Materials. This should give the total cost of the bill of materials including estimated cost of each major item. Include lead time of critical items. U.S. investigators seeking to obtain TM data directly from NASA should not include the cost of such data in their proposals. However, U.S. investigators will be responsible for procuring all other forms of space-acquired data to be used in their investigations, and the cost of procuring such data should be included here.

d. Subcontracts. List those over $10,000; specify the vendor and the basis for estimated costs. Include any baseline or supporting studies.

e. Special Equipment. Include a list of special equipment and lead and/or development time.

f. Travel. List estimated number of trips, destinations, duration, purpose, number of travelers, and anticipated dates.

g. Other Costs. Cost not covered elsewhere.

h. General and Administrative Expense. This includes the expenses of the institution's general and executive offices and other miscellaneous expenses related to the overall business.

i. Fee (if applicable).

2. COST SCHEDULE

Separate schedules, in the above format, should be attached to show total cost allocable to the following:

a. Principal investigator and scientific collaborator costs.

b. Data reduction and analysis including the amount and cost of computer time.

c. Cost of correlative data (if any) to be acquired by the investigator.

d. Cost of extended field studies in excess of $10,000 to support TM image analysis and interpretation.

Proposals for multiyear investigations should present cost schedules on an annual basis.

APPENDIX C

RELEVANT TECHNICAL PUBLICATIONS

Bauer, M. E. (ed.), Remote Sensing of Environment: AgRISTARS Special Issue. Vol. 14, Nos. 1-3, 278 p., 1984.

Colwell, R. N. (ed.), Manual of Remote Sensing, Second Edition, available from the American Society of Photogrammetry, 210 Little Falls Street, Falls Church, VA 22046, 2440 p., 1983.

Deutsch, M., Wiesnet, D. R., and A. Rango (eds.), Proceedings of the Pecora V Symposium on Satellite Hydrology, available from the American Water Resources Association, Mississippi River at 3rd Avenue, S.E., Minneapolis, MN 55414, 730 p., 1981.

Goetz, A. F. H., Rock, B. N., and L. C. Rowan, Economic Geology: Remote Sensing Techniques and Results Special Issue. Vol. 8, No. 4, p. 573-782, 1983.

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